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FOSSIL PLANTS FROM THE INTERTRAPPEAN BEDS OF MOHGAON KALAN, IN THE DECCAN, WITH A SKETCH OF THE GEOLOGY OF THE CHHINDWARA DISTRICT

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SUMMARY

In Part I four species of fossil fruits from Mohgaon Kalan are described and figured. The flora of this locality, considered as a whole, is regarded as early Tertiary, and most probably Eocene.

In Part II the geology of the district is described. The plant-bearing beds at Mohgaon Kalan are shown to belong definitely to an Intertrappean horizon only about 100-130 ft. above the base of the Deccan Trap series.

The conclusion is that the Deccan Trap in the Chhindwara district is definitely of Tertiary age, as suggested by the pioneer geologists just a hundred years ago, and not Upper Cretaceous as was almost universally believed by geologists till 1934 when one of us made a comprehensive review of the Deccan Intertrappean flora.

PART I

Fossil Plants from Mohgaon Kalan

By B. Sahni

Introduction

A few years ago the author [10, 11] showed that a comprehensive review of the flora of the Deccan Intertrappean series strongly supported the original view, now a hundred years old, that the Deccan Traps are of Tertiary age, not Upper Cretaceous

as was almost universally believed till 1934. The Benares geologist Professor K. P. Rode having discovered "*Nipadites*" and other palm fruits, stems etc., in the Chhindwara District (a classical area where the pioneer geologists had worked) it was important that the small but interesting flora collected by him should be described in detail. Some of these plant remains were described at my suggestion by Prof. Rode himself, but he very kindly allowed me to undertake a more detailed description of the silicified fruits, both from the botanical point of view and with due regard to their stratigraphical affinities. He also readily fell in with my suggestion that he should make a careful geological survey of the Mohgaon area to establish beyond doubt the exact position of the plant-bearing beds in the series. He has now proved that the flora, which I regard as most probably Eocene, comes from an intertrappean horizon which although not quite at the base of the series is underlain by only about 100—130 ft. of the oldest traps. The higher members of the series, at least in the Nagpur-Chhindwara area, must therefore *a fortiori* be of Tertiary age. But in fairness to Prof. Rode I must add that our collaboration in the present publication in no way commits him to my views concerning the age of the Deccan Traps, which are based solely on the affinities of the flora.

Description

List of species from Mohgaon Kalan (collected by Rode 1929-30, and later by Prof. S. P. Agharkar, Prof. P. Parija, and the writer).

Palmae. ***Nipa hindi*** (Rode) Sahni, ***Tricoccites trigonum*** Rode, ***Palmocarpon compressum*** (Rode) Sahni, ***Palmoxylon Hislopi*** Rode, ***P. kamalam*** Rode, ***P. Sahnii*** Rode, ***P. solidum*** Rode, ***P. mohgaoensis*** Rode, ***P. invaginatum*** Rode, ***Rhizopalmoxylon penchiensis*** Rode.

Dicotyledones. ***Dryoxylon mohgaoense*** Rode, ***Phyllites mohgaoensis*** Rode. ***Enigmocarpon Parijai*** Sahni.

Palmae

Nipa hindi (Rode) Sahni

Pl. I figs. 1—3.

1933 *Nipadites hindi* Rode[6]

Diagnosis. ***Drupe quadrangular throughout its length, suggesting a compound fruit derived from a capitulum; umbo well defined. Solitary specimen ca. 4·75 cm. long, ca. 4 cm. in its broadest distal part. Epicarp membranous, smooth; sarcocarp 2·13 mm. thick; endocarp ca. ·3 mm. thick. Seed roughly spherical ca. 2-2·5 mm. diam., sulcus 1 cm. broad, shallow, not reaching the apex; endocarp not projecting into sulcus; germinal aperture 9 × 13 mm.***

The smooth membranous epicarp is peeled off in places to expose the fibrous sarcocarp which has an outermost layer of specially thick longitudinal fibres. The seed coat is clearly seen in fig. 3 as a dark layer where it dips to form the broad sulcus;

its outer surface is marked with reticulate vein impressions. The endosperm is not preserved, the cavity being filled with silica. Rode's description is inaccurate in a few points. The seed is not smooth, but distinctly grooved as in the modern *Nipa fruticans*, though the sulcus in the fossil is much wider and has no endocarp ridge dipping into it. The basal aperture is not a cavity left by a broken-off stalk, but a germinal pore for the embryo, and a characteristic feature of the genus. The similarity with the modern *Nipa* extends to almost all the distinctive features. I have therefore no hesitation in referring the fossil to *Nipa*. The Deccan species differs from Brongniart's[4] in the form of the drupe, its very broad sulcus, and in other features. It is the best preserved species so far known. It appears that Hislop had already discovered this genus in the Deccan long ago. He mentions it more than once (1, p. 718; 2, p. 68; 3), but his original specimen or specimens can no longer be traced. In the fossil form this genus is eminently characteristic of the Eocene, no younger records being yet known ; Reid and Chandler have convincingly shown that nearly all its records lie approximately along the shore of the Nummulitic sea (Tethys), which thus probably passed not far north of the latitude of Chhindwara.

Tricoccites trigonum Rode[6]

Pl. I figs. 4—6.

Diagnosis. *Drupe 3-loc., 3- seeded, one seed sometimes abortive. L.S. obovate 3-4 cm. long, 2½ to 3 cm. in the widest distal part; apex acute or acuminate. Mode of attachment unknown. Cross-section roundly triangular; epicarp thin, smooth; sarcocarp ca. 3 mm. thick, with radial plates of hard tissue dividing it into about 20 longitudinal segments of which the central (? thin-walled) tissue is not preserved. Endocarp under 1 mm. thick, sending inwards 3 septa which meet in a central axis containing a strand of fibres. The septa lie at right angles to the sides of the cross-section of the fruit. Loculi ca. 10 mm. across, smooth. Seed-casts oblong, ca. 9 × 18 mm., smooth; embryo not preserved; placentation unknown.*

Rode's choice of the new generic name *Tricoccites*, influenced by a supposed affinity with the modern genus *Tricoccus*, is unfortunate. Apart from the trilocular character and large seeds there is nothing to suggest an affinity with the Euphorbiaceae. But as the fruit is of a very characteristic type and should be recognised as a new genus the name *Tricoccites*, however misleading, must under the rules of nomenclature be adopted. It should be clearly understood that it has nothing whatever to do with the modern *Tricoccus* or indeed with any dicotyledons. The whole organisation of the fruit suggests that it belongs to a palm. The "cup-like receptacle carrying the stalk of the fruit" mentioned by Rode is not preserved in any specimens I have seen but if his description is correct the "receptacle" would probably represent either a persistent perianth or bracteoles, such as are commonly seen on palm fruits. The longitudinal strips into which the sarcocarp is divided

by the radial plates are not "fluid canals" but were probably occupied by a relatively delicate tissue, possibly an aerenchyma aiding the transport of the fruit by water (cf. *Enigmocarpon*, below).

Palmocarpon compressum (Rode) Sahni

Pl. I fig. 7

1933 Nipadites compressus Rode Sahni

Diagnosis. *Drupes of varying form (? partly istorted), ca. 3·5 to 4·5 cm. in the broadest part, length in the biggest specimen ca. 8 cm. Outer surface faintly divided into longitudinal strips converging to the obtusely rounded apex. Epicarp thin, smooth; sarcocarp thick, fibrous; endocarp (?). Seed probably solitary, large, oblong.*

It is very difficult to decide whether this is a *Nipadites* or some other type of palm fruit. In the figured specimen the transversely fractured surface faintly shows the outline of the large seed dipping on one side to form what may be a normal sulcus like that of *Nipa*, but the preservation is not clear. The species is provisionally placed under *Palmocarpon* pending the discovery of better preserved specimens.

Palmoxylon Hislopi Rode, *P. kamalam* Rode, *P. Sahnii* Rode.

These are three tolerably well preserved woods[5] which call for no special remarks. Rode[7,8] mentions several other species of palm stems and roots but these have not yet been described or figured (see list above).

DICOTYLEDONES

The affinities of all the dicotyledonous remains are obscure. The wood *Dryoxylon mohgaoense* [9] is considered by Rode to show the nearest affinity with the Combretaceae. The leaf *Phyllites mohgaoense* is a solitary fragment of unknown attribution.

Enigmocarpon Parijai Sahni [11]

Pl. I figs. 8-15

Diagnosis. ***Fruit syncarpous, ellipsoid, usually ca. 14 × 18 mm., circular in cross-section, 8-loc. (rarely 9-loc.), the thin septa radiating from a thick axile placenta. Ovules anatropous, elongated, about 18 per loculus, placed horizontally in 2 vertical rows. Ovary wall 2-3 mm. thick, of spongy aerenchyma (aquatic dispersal), external surface smooth. Mode of dehiscence loculicidal.***

Several specimens were collected, some by Rode [6] in 1929-30, others by Prof. Parija and myself[11] in January 1931. Attempts were made to determine the affinities by comparing a large number of modern fruits at Kew, the British Museum and elsewhere, but without any encouraging result. Detailed comparisons will be given elsewhere.

Geological Age

The outstanding feature of this small flora, so far as it is known, is the large proportion of palms. There are three species of fruits and at least six of stems belonging to this family, besides the roots mentioned by Rode which may have belonged to one of the stems. The *Nipa* fruit cannot have belonged to one of these *Palmoxyla*, because the stem structure of this genus is very distinct. Even assuming that both the other fruits belonged to two of the *Palmoxyla* we would have seven species of palms in a flora which apart from this family only includes three dicotyledons (a leaf, a wood and a fruit). It is very unlikely that further discoveries will seriously lower this proportion, for most of the new specimens that turn up are palms. I have elsewhere shown that the same preponderance of palms is seen in the Deccan Intertrappean flora as a whole. As this family did not rise into prominence till the middle Tertiaries the Mohgaon flora cannot very well be much older than Oligo-Miocene. And the existence of an undoubted species of *Nipa*, a genus of which the fossil records are nearly all Eocene, seems strongly to support an Eocene age. The pioneer view regarding the age of the Deccan Traps is thus confirmed even by a study of this small local flora.[12]

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Explanation of Plate I

All the figures are from untouched photographs, and except where otherwise stated, they are of the natural size. *Loc.* Mohgaon Kalan, C. P. (22°1'; 79°11'), *horizon* 100-130 ft. above the base of the Deccan Trap. The originals of figs. 4-6, 8 and 10 are in the Sahni Collection, those of figs. 1-3, 7, 9, 11-15 in the Benares University Geol. Dept.

Figs. 1-3. *Nipa hindi* (Rode) Sahni. 1, entire drupe, oblique view; 2, basal view showing germinal aperture; 3, cross-section showing three layers of carpel wall, seed-coat and sulcus.

Figs. 4-6. *Tricoccites trigonum* Rode. 4, external view, epicarp locally destroyed, exposing longitudinal strips of sarcocarp with their separating ribs; the acuminate apex is indistinct. 5, longitudinally fractured fruit, showing acute apex. 6, cross-section.

Fig. 7. *Palmocarpon compressum* (Rode) Sahni.

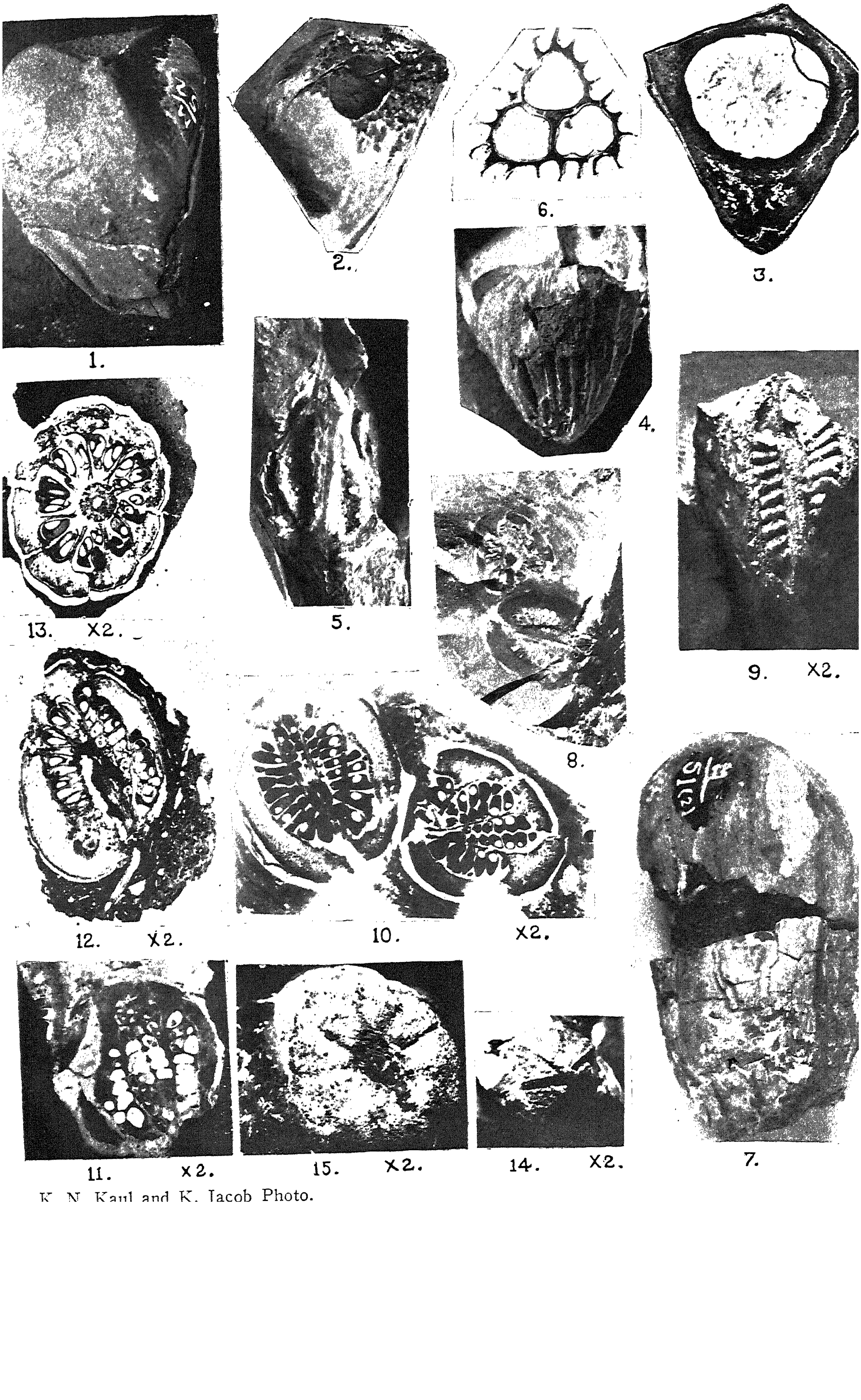
Figs. 8-9. Opaque views of fruits fractured in different planes. 8 nat. size, 9 × 2.

Figs. 10-12. Thin sections (all tangential) showing arrangement of ovules, septa and spongy carpel wall. In fig. 12 the stalk of the fruit is seen obliquely placed at the lower end. All × 2.

Fig. 13. Transverse section showing the central axis, the eight radial septa, and the loculicidal dehiscence × 2.

Fig. 14. View of distal end of a dehisced fruit × 2.

Fig. 15. End view of an unusually large fruit with 9 loculi; the radiating dark lines are grooves along which dehiscence occurs. The dark central patch is a mass of cherty matrix lying in a depression in what is probably the basal end of the fruit × 2.



K. N. Kaul and K. Jacob Photo.

PART II

A Sketch of the Geology of the Chhindwara District with special reference to the angiosperm bearing horizons

By K. P. Rode

The Deccan Traps have long been known to contain nicely petrified plants in their sedimentary horizons and good collections had been made in the middle of the last century by Hislop and Hunter. [5, 6, 8] These pioneer workers, however, restricted their investigations to the faunal remains[7] found associated with plants, while their plant collections were never properly described, though in a general way the flora was classed as Eocene and compared with that of the London Clay.

The palaeobotanical interest in these horizons, however, has been revived in recent years by the discovery of certain highly fossiliferous localities in the Central Provinces. Of these, Sausar[17] and Mohgaon Kalan [12, 13, 15,] both in the Chhindwara District, are specially noteworthy in that they have yielded plant material which appears to throw much light on the vexed question of the age of the Deccan Traps.[16] In view of this stratigraphical importance the author has given in the following few pages, a brief sketch of the geology of the Chhindwara District with special reference to the position of the plant bearing beds.

The Chhindwara District is bounded by Lat. 21°30′–22°50′N. and Long. 78°15′–79°20′E. and comprises of a peneplane on the south, a plateau in the middle and a hill tract on the north.

The principal rock formations occurring in the district are the Pre-Cambrian Metamorphics, the Gondwanas and the Deccan Traps (map fig. 1). The Pre-Cambrians include the Dharwar Schists constituting the manganiferous Sausar series and typically occurring in the southern peneplane, while the granites and gneisses which form the basal rocks occur chiefly in the western part of the district and in the Kanhan Valley. The Gondwanas, which overlie the Archaeans directly, are confined to the north-western portion and include both the lower and the upper divisions of the system, the former being responsible for the coal formations of the Pench Valley and the latter culminating in the prominent Pachmarhi Hills. The next important rock-formation is the Deccan Trap which overlies all the older formations with great unconformity, its junction with the older rocks being often characterised by the occurrence of a thin strip of unfossiliferous Infra-trappeans, the so-called Lametas of somewhat uncertain origin and age.

The Deccan Traps occupy nearly three-fourths of the area in the district, covering the eastern part of the Chhindwara and Amarwara Tahsils and also the

western half of the Sausar Tahsil. From their extensive field experience of the Deccan Trap region Medlicott and Blanford[1, 10] regarded the Nagpur traps as amongst the lowermost flows of the Deccan Trap series. Fermor and Fox who have closely studied the traps of Linga, 8 miles south of Chhindwara, agree with the above view and go farther to suggest that the Linga trap 'may well prove to be the first flow of the Deccan Series of which we have any trace.'[4] The Chhindwara traps have been studied in great detail and a number of chemical analyses [2, 3] are available for rocks from this area. They go to show that these traps are typical 'plateau basalts' often containing olivine but poor in alkalis. They represent the composition of the main trappean magma prior to its differentiation into acidic and ultra-basic components.

The traps in this district are rarely more than three to four hundred feet thick except in the Mahadeo Hills[9] to the north where they are estimated to be as thick as 1200—1500 ft. The variation in structure and texture, as also the presence of thin sedimentary layers, has made it possible to distinguish, as in the Linga area, several distinct flows with an individual thickness of about 60 ft. It is the thin sedimentary layers occurring sandwiched between the trap flows that have preserved the remains of the terrestrial and fresh water life of the Deccan trap period. The author has made a large collection of fossil plants from the beds of Mohgaon Kalan (22°.1′, 79°.11′) and Umaria Isra (22°.3′, 79°.5′)[14] both to the east of Chhindwara, and a careful study of the field relations of these fossiliferous beds has proved their truly intertrappean nature (map fig. 2).

The sedimentary bands, as exposed in these two areas, include pink and variegated shales and clays, brown and buff coloured hard cherts, indurated jasperoid rocks of oily green appearance and unstratified tuffs composed of trappean ash and silt. Among the fossils so far collected from these bands the plant material is all angiospermous consisting of a number of palms and dicotyledonous genera, while among the fossil invertebrates *Bullinus prinsepii* is by far the most abundant.

The sedimentary bands have been traced over large areas in the neighbourhood of Mohgaon and Umaria Isra but in most cases they are met with as detached patches, often only as stray blocks strewn over the fields; only in a few cases have they been found as continuous beds running for any distance. This is partly because they have suffered extensive breaking and denudation and also because their outcrops have been obscured by the admixture and covering of thick trappean soil. The true mode of occurrence of these rocks is, however, nicely exhibited in the hill north-west of Umaria Isra. At the foot of the hill below the 2100′ contour, there is an unfossiliferous bed of variegated shales about 15—20 ft. thick, resting on a trappean base. Above this bed and separated from it by an intervening flow of trap, is another, fairly fossiliferous, sedimentary band traced along the 2150′ contour for over two miles, which again is covered by a good thickness of the traps (Section

Fig. 3B). There are thus in this area at least two sedimentary bands, interstratified with the trap flows.

In the Mohgaon area also a fairly thick and highly fossiliferous chert bed is exposed on the 1950′ contour in a valley about a mile north of Paladon, distinctly underlain and overlain by basaltic flows (Section Fig. 3C). This band is met with, though somewhat interruptedly, along the same contour, near Paladon proper to the west, Udadon to the north, Mohgaon to the east and Keria and Jhiria to the south (map fig. 2).

These field relations prove beyond doubt that the plant-bearing sedimentary beds are of strictly intertrappean nature.

It may be noted here that the Archaean base of the traps in this district is not a horizontal surface but shows a definite, though gentle, slope from Chhindwara (2250 ft.) eastward until about 6 miles east of Mohgaon it outcrops at 1800 ft. (Section Fig. 3A). It may therefore be safely inferred that the Archaean base below the Mohgaon-Paladon tract may be only slightly above 1800 ft., in which case the depth of the traps below the intertrappean band (1950 ft.) may not be more than 100—130 ft. above the Archaean base. Similar considerations give nearly the same thickness for the traps below the Umaria Isra intertrappeans. This is most strikingly corroborated by the fact that nearly identical relations have been observed in the adjoining district of Betul.[11]

It thus appears clear that the known plant-bearing horizons are truly intertrappean in nature, that they are not quite basal but are underlain by a small (100—130 ft.) thickness of traps and that these horizons are associated with the lowest traps occurring in the district.

I am very thankful to Dr. B. Sahni for giving me this opportunity to collaborate in this joint paper on the Intertrappeans.

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Explanation of Figs. 1—3

Fig. 1. Geological Map of the Chhindwara District showing the position of the Angiospermous plant beds. Scale 1″ = 8 m. (Based on Geological Survey of India Publication 1931.)

Fig. 2. Map showing the outcrop of the Intertrappean beds of Umaria Isra and Mohgaon Kalan (by K. P. Rode) Scale 2″ = 1 mile. (Enlarged from Survey Sheet No. 55 N/4.)

Fig. 3. Sections :— (A) Section A-A across the district roughly W.N.W.-E.S.E. passing through Chhindwara town, Umaria Isra and Mohgaon Kalan. Horizontal Scale 1″ = 8 m., Vert. Scale 1″ = 2,000 ft.

(B) Section B-B of the hills near Umaria Isra Hori. Scale 3″ = 1 m. Vert. Scale 1″ = 200 ft.

(C) Section C-C roughly N.W.N.—S.E.S. passing through Mohgaon Kalan. Horiz. Scale 2″ = 1 m. Vert. Scale 1″ = 200 ft.

FUNGI OF MUSSOORIE

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SUMMARY

Ninetynine fungi have been described. Of these 9 are new species of which descriptions are given and 11 are on new hosts.

The fungi in this list were collected by the authors from 1930 to 1934 during the months of May, June, September and October. They were collected in the town of Mussoorie including such spots as the Kamptee Falls and Mossy Falls and also on the road from Rajpur to Mussoorie.

Eleven species, marked with an asterisk, are on hosts on which they were not found previously and which are not mentioned in "The fungi of India" by Butler and Bisby.

Nine species, marked with a double asterisk, are new to science, being described in the "Annales Mycologici" Fungi indici, Nos. I & II, by H. Sydow and J. H. Mitter and No. III, by Sydow, Mitter and R. N. Tandon. The descriptions of the new species are by Mr. Anil Mitra of this Department and have been translated and adapted for this paper from the above publications.

Sixteen of these fungi, marked with a X, are not mentioned in the "Fungi of India" by Butler and Bisby.

Lastly, for over 50% of the fungi in this list, Mussoorie is a new locality.

No.	Name of the fungus.	Name of the host.
	PHYCOMYCETES	
1	*Cystopus bliti* (Biv.) de Bary.	*Achyranthes aspera.*
*2	*Cystopus bliti* (Biv.) de Bary.	*Cyathula capitata.*

No.	Name of the fungus.	Name of the host.
	ASCOMYCETES	
3	*Erysiphe polygoni* DC.	*Rumex nepalensis.*
4	*Exoascus deformans* (Berk.) Fckl.	*Prunus persica.*
*5	*Phyllachora desmodii* P. Henn.	*Desmodium tiliaefolium.*
X6	*Phyllachora premnae* Syd.	*Premna pinguis.*
**7	*Phyllachora tandonii* Mitter.	*Ficus foveolata.*
*8	*Taphrina maculans* Butl.	*Globba racemosa.*
*9	*Taphrina maculans* Butl.	*Hedychium acuminatum.*
10	*Schizothyrium annuliforme* Syd & Butl	*Acer oblongum.*
11	*Uncinula salicis* (DC.) Wint.	*Salix dephnoides.*
	BASIDIOMYCETES	
	(*a*) USTILAGINALES	
X12	*Melanotaenium selaginellae* Syd.	*Selaginella chrysocaulos.*
X13	*Melanotaenium selaginellae* Syd.	*Selaginella chrysorrhizos.*
	(*b*) UREDINALES	
X14	*Aecidium berberidis* Gmel.	*Berberis asiatica.*
15	*Aecidium crypticum* Kalchbr. and Cke.	*Gerbera lanuginosa.*
16	*Aecidium montanum* Butl.	*Berberis aristata.*
*17	*Aecidium montanum* Butl.	*Berberis asiatica.*
18	*Aecidium montanum* Butl.	*Berberis lycium.*
*19	*Aecidium orbiculare* Barclay.	*Clematis triloba.*
**20	*Aecidium tandonii* Mitter.	*Deutzia staminea.*
21	*Aecidium tweedianum* Speg.	*Dicliptra bupleuroides.*
22	*Chnoopsora sancti-johannis* (Barclay) Diet.	*Hypericum cernuum.*
23	*Coleosporium campanulae* (Pers.) Lev.	*Campanula colorata.*
*24	*Coleosporium campanulae* (Pers.) Lev.	*Lobelia affinis.*
25	*Coleosporium clematidis* Barclay.	*Clematis montana.*
26	*Coleosporium clematidis* Barclay.	*Clematis triloba.*
27	*Coleosporium inulae* (Kunze) Rabenh.	*Inula cappa.*
28	*Coleosporium leptodermidis* (Barclay) Syd.	*Leptodermis lanceolata.*
29	*Coleosporium plectranthi* Barclay.	*Plectranthus gerardianus.*
30	*Gambleola cornuta* Massee.	*Berberis nepalensis.*
31	*Gymnosprangium Cunninghamianum* Barclay.	*Pyrus pashia.*
32	*Melampsora ciliata* Barclay.	*Populus ciliata.*
33	*Melampsora yoshinagai* P. Henn.	*Wikstroemia canescens.*
34	*Monosporidium andrachnis* Barclay.	*Andrachne cordifolia.*
35	*Peridermium brevius* (Barclay) Sacc.	*Pinus excelsa.*
36	*Peridermium orientale* Cke.	*Pinus longifolia.*

No.	Name of the fungus.	Name of the host.
37	*Phakopsora cronartiiformis* (Barclay) Diet.	*Vitis himalayana.*
38	*Phragmidium barclayi* Diet.	*Rubus lasiocarpus.*
39	*Phragmidium rosae-moschatae* Diet.	*Rosa moschata.*
X 40	*Puccinia ainsliaeae* Syd.	*Ainslia pteropoda.*
41	*Puccinia collettiana* Barclay.	*Rubia cordifolia.*
*42	*Puccinia fagopyri* Barclay.	*Fagopyrum cymosum.*
*43	*Puccinia fagopyri* Barclay.	*Fagopyrum tataricum.*
44	*Puccinia himalensis* Barclay.	*Rhamnus virgata.*
45	*Puccinia komarovi* Tranz.	*Impatiens* sp.
46	*Puccinia lateritia* Berk. and Curt.	*Spermococe stricta.*
*47	*Puccinia leucophaea* Syd. and Butl.	*Colquhounia vestita.*
48	*Puccinia nepalensis* Barclay and Diet.	*Rumex nepalensis.*
**49	*Puccinia oreogeta* Syd.	*Carex condensata.*
50	*Puccinia polliniae* Barclay.	*Strobilanthes dalhousianus.*
51	*Puccinia polliniae* Barclay.	*Strobilanthes pentstemonioidis.*
52	*Puccinia prainiana* Barclay.	*Smilax aspera.*
53	*Puccinia roscoeae* Barclay.	*Roscoea procera.*
54	*Puccinia roscoeae* Barclay.	*Roscoea purpurea.*
55	*Puccinia saxifragae-ciliatae* Barclay.	*Saxifraga ciliata.*
56	*Puccinia saxifragae-ciliatae* Barclay.	*Saxifraga ligulata.*
57	*Puccinia taraxaci* (Rebent.) Plowr.	*Taraxacum officinale.*
58	*Puccinia urticae* Barclay.	*Urtica parviflora.*
59	*Puccinia violæ* (Schum.) DC.	*Viola canescens.*
60	*Puccinia violæ* (Schum.) DC.	*Viola* sp.
61	*Puccinia wattiana* Barclay.	*Clematis buchananiana.*
62	*Puccinia wattiana* Barclay.	*Clematis gouriana.*
**63	*Pucciniastrum aceris* Syd.	*Acer cultratum.*
64	*Pucciniastrum agrimoniæ* (Schw.) Tranzsch.	*Agrimonia pilosa.*
65	*Pucciniastrum coriariæ* Diet.	*Coriaria nepalensis.*
X66	*Pucciniastrum coryli* Kom. et Tranzsch.	*Corylus colurina.*
67	*Pucciniostele clarkiana* (Barclay) Diet.	*Astilbe rivularis.*
X68	*Uredo alpestris* Schroet.	*Viola serpens.*
X69	*Uromyces capitatus* Syd.	*Desmodium tiliæfolium.*
70	*Uromyces mac-intirianus* Barclay.	*Hemigraphis latebrosa.*
X71	*Uromyces valerianæ-wallichii* (Diet) Arth. et Cumm.	*Valeriana wallichii.*
	(c) HYMENOMYCETES	
72	*Fomes rimosus* Berk.	
X73	*Fomes robustus* Karst.	
74	*Fomes senex* Nees and Mont.	
75	*Ganoderma lucidum* (Leyss) Karst.	
76	*Hydnum sp.*	
77	*Lenzites sepiaria* (Wulf.) Fr.	

No.	Name of the fungus.	Name of the host.
78	*Polystictus hirsutus* Fr.	
79	*Polystictus sanguineus* (L.) Mey.	
80	*Polystictus versicolor* (L.) Fr.	
81	*Schizophyllum commune* Fr.	
82	*Sterium hirsutum* (Willd.) Fr.	
83	*Sterium* sp.	
84	*Trametes Persooni* Fr.	
	(*d*) GASTEROMYCETES	
85	*Geaster lageniformis* Vittadini.	
86	*Lycoperdon* sp.	
87	*Scleroderma* sp.	
	FUNGI IMPERFECTI	
**88	*Cercoseptoria balsaminæ* Syd.	*Impatiens balsamina.*
**89	*Cercospora cyathulæ* Syd.	*Cyathula tomentosa.*
**90	*Chætomella indica* Syd.	*Coriaria nepalensis.*
*91	*Cicinnobolus cesatii* de Bary.	*Cucurbita* sp.
**92	*Coniothyrium deviatum* Syd.	*Populus ciliata.*
X93	*Papularia arundinis* (Corda) Fr.	Ornamental bamboo.
X94	*Phyllosticta hederacea* (Arc.) Allesch.	*Hedera helix.*
**95	*Sarcinella oreophila* Syd.	*Carissa Carandus.*
X96	*Septoria thalictri* Ell. et Ev.	*Thalictrum javanicum.*
X97	*Systremma natans* (Tode) Theiss. et Syd.	*Berberis lyceum.*
X98	*Titæosporina tremulæ* (Lib.) v Luyk.	*Populus ciliata.*
X99	*Tuberculina costaricana* Syd.	*Vitis himalayana.*

DESCRIPTIONS OF THE NEW SPECIES

Phyllachora Tandonii, Mitter, nov. spec. On leaves of *Ficus foveolata*

Stromata on the upper surface of the leaf, close to each other, chiefly circular, 1-2 m.m. in diameter; only a few sterile ones on the lower surface; clypeus 30—100μ in thickness, black, 1-many locular; loculi 200—350 × 150—300μ; asci cylindrical clavate, nearly sessile, 8-spored, 50—70 × 12—16μ; ascospores in one oblique row, ellipsoid or oblong, hyaline, 13—15 × 6—7μ; paraphyses numerous, about 2μ broad.

Aecidium Tandonii, Mitter nov. spec. On leaves of *Deutzia staminea*

Spermagonia in the centre of yellowish spots on the upper surface; aecidia on the under surface, cylindrical, 1-2·5 m.m. in length, deep yellow; peridial cells

rhomboidal 26—34 x 14—20μ, outer wall slightly striate; aecidiospores globose to slightly angular almost smooth, 17—21 x 16—18·5μ, membrane hyaline, about 1μ broad.

Puccinia Oreogeta, Syd. nov. spec. On leaves of *Carex condensata*

Uredosori on the under surface of the leaf, scattered, oblong 200—300μ long, covered with epidermis, yellow; uredospores chiefly ovate, 22—30 x 17·22μ, densely spiny, wall nearly hyaline, about 1·5μ thick, germ-pores indistinct; teleutosori similar, brown; teleutospores oblong to clavate, mostly rounded at the apex, slightly constricted at the septum, gradually attenuated below, 35—52μ long; upper cell 16—21μ, lower cell mostly a little longer and narrower; epispore yellow brown; stalk persistant 25—45μ long nearly hyaline.

Pucciniastrum aceris, Syd. nov. spec. On leaves of *Acer cultratum*.

Uredosori on the under surface of the leaf below the epidermis 80—120μ in diameter; uredospores nearly globose, 17—20 x 14—16μ, minutely spiny, wall hyaline about 1μ thick; teleutosori formed like a crust on the under surface below the epidermis; at first yellow, later becoming dark; teleutospores laterally placed, 20—30μ high, vertically septate or obliquely divided, epispore about 1μ thick, hyaline to pale brown.

Cercospora cyathula, Syd. nov. spec. On leaves of *Cyathula tomentosa*

Patches always on the under surface producing on the upper surface irregular yellow discolorations. Hyphae nearly hyaline, 2·5—4μ broad, irregularly branched; conidiophores short, simple or branched septate, often chainlike in appearance, lightly coloured, 4—5·5μ thick; conidia hardly attenuated, variously curved, 2—7μ septate, lightly coloured 30—100 X 5—7μ.

Cercoseptoria balsaminae, Syd. nov. spec. On leaves of *Impatiens balsam*.

Spots irregular, borne on both sides, ·5—1 cm. in diameter, dirty yellow brown; conidiophores short, nearly filiform, 6—12μ long, basal part 2·5—3μ broad, more or less pointed at the tip, nearly hyaline; conidia filiform, base rounded, tip gradually pointed, curved, hyaline, indistinctly septate, 35—100μ long and 1·5—2·5μ broad at the base.

Coniothyrium deviatum, Syd. nov. spec. On wilted leaves of *Populus ciliata*

Spots on both sides, ·5-2 cm. in diameter, greyish-brown on upper surface and rusty on the under; pycnidia on the upper surface generally, flattened and circular, 50—100μ in diameter, unilocular or incompletely loculed; ostiole flatly papillate, pore 10μ broad, protruded; conidia ovate or ellipsoid, 1 celled, hyaline to brownish 4—6·5 x 3—4·5μ.

Sarcinella oreophila, Syd. nov. spec. On living leaves of *Carissa spinarum*

No spots, tufts on the under surface of the leaf, irregular, darkish; mycelium reticulately branched, pale dark brown, septate, 4—5μ broad; hyphopodia frequent, solitary, globose, 1 celled, 7—9μ in diameter, conidia borne laterally or at the apex of hyphae, orbicular, 20—35μ in diameter, dark brown.

Chaetomella indica, Syd. nov. spec. On living leaves of *Coriaria nepalensis*

Pycnidia on the under surface of the leaf, in brownish spots, superficial; when dry cup-shaped, amber coloured, 200—400μ in diameter, when wet convex, entirely closed, without ostiole; open irregularly on maturity; hairy outside; hairs erect, simple, septate, 50—150μ long, 7—10μ broad at the base which is chestnut-brown, lighter coloured at the narrower tip; conidiophores up to 25μ broad, hyaline or nearly so, cellular, once or twice dichotomously branched; conidia borne at the tip, narrowly spindle-shaped, tips obliquely attenuated, thus appearing boat-shaped, hyaline, 1 celled, 8—11·5 × 1·7—2·5μ.

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ON THE SALIVARY GLANDS IN THE ORDER COLEOPTERA, PART I
THE SALIVARY GLANDS IN THE FAMILY TENEBRIONIDAE

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SUMMARY

1. Salivary glands, so far known to exist only in a few species of Coleoptera, have been found to be of common occurrence in the family Tenebrionidae.

2. These salivary glands are simple tubular structures of variable length not very much unlike those found in some other orders such as Lepidoptera and Psocoptera. In Blapsidae they assume the character of ramifying tubes due to secondary branching.

3. The ducts of the two sides do not unite to form a common salivary duct but open separately in the preoral cavity.

4. Similar tubular salivary glands have also been observed in a number of species belonging to families Coccinellidae, Cerambycidae and Curculionidae.

INTRODUCTION

The salivary glands in the order Coleoptera are known to exist only in a few species and our knowledge of them is very meagre. Imms[2] writes, "The salivary glands (in the Coleoptera) appear to have been very little investigated and they are wanting in many species." Packard[4] records three pairs of salivary glands in the head of *Anophthalmus* (Carabidae). Dufour[1] describes simple tubular salivary glands in *Pyrochroa coccinea* (Pyrochroidae); while in Blapsidae[4] they are known to consist of many ramifying tubes which unite on each side of the oesophagus into a single duct. Apart from these salivary structures, unicellular glands with intracellular ducts are known to exist in the wall of the foregut of many Lamellicorn beetles, which are believed to be salivary in function.[5] In view of the fact that the salivary glands are present as definite structures in nearly all the other orders of Insecta, it is of interest to ascertain why they are so poorly represented in a big order like Coleoptera, which comprises both herbivorous and carnivorous forms.

I started my work with a view to find out the distribution and condition of salivary glands in this order, and have succeeded in locating them in a large number of forms in which, so far as I am aware, they have not been recorded before. Further I am inclined to think that they are present in a large number of other forms and that in some families at least, such as Tenebrionidae and the Coccinellidae, they are universally present.

The present paper embodies my observations on the salivary glands in the family Tenebrionidae only and I propose to describe these glands as they occur in other families in subsequent papers.

MATERIAL AND METHODS.

The beetles of the family Tenebrionidae provide a very suitable material for work, as most of them are found in abundance in all seasons and, secondly, because they can remain alive for a much longer time under suitable conditions of temperature and nourishment in the laboratory. Being the largest family among the Coleoptera, comprising more than 10,000 species, of which about 300 are found in India, I directed my attention to the most commonly occurring species of the plains and began my work upon them. Care was, however, taken to select species differing in their feeding habits to see if the occurrence and structure of the salivary glands was at all affected by the nature of their food.

Specimens of *Alphetobius diaperinus* Panz. were collected in large numbers during the months of July, August and September from pigeon-cages where they probably live on the excreta of these birds. Specimens of *Opatrinus punctulatus* Brull. were found abundantly near heaps of cowdung at all times of the year. They were also found in fields among fallen leaves. *Curimosphaena fasciculatus* F. was also found near cowdung along with *Opatrinus punctulatus* but only during the months of August and September. Specimens of *Himatismus vageguttatus* Fairm., *Gonocephalum brachelytra* Gebien., *G. elongatum* Fairm., *G. hoffmannsegi* Stev. and *Hyperops lata* Kraatz. were found in large numbers in fields and in places where fallen leaves are accumulated for the purpose of making leaf-moulds. Of these *Himatismus* and *Hyperops* were common in summer months, from April to August, while species of *Gonocephalum* were found in winter also. *Scleron reitteri* Geb. was obtained from fields occasionally in the rainy season and specimens of *Lasiodaclytus marcuatipes* were collected near about the street lights. Specimens of *Gonocephalum strigatum*, *Scleron latipes* and *Adavius claripes* Muls. were collected from grass fields near the river during the months of July and August. *Rhytinota impolita* Fairm. was the only species, probably living on stored grains, which was collected from houses during August, September and October. *Tribolium ferrugineum* is commonly found in flour.

Dissections were made chiefly on fresh specimens and only in some cases on specimens kept in the laboratory under suitable conditions. Specimens were dissected in normal salt solution under a binocular microscope. The salivary glands because of their minuteness and superficial resemblance to muscle-fibres amongst which they remain coiled, are slightly difficult to locate at first sight. In order to overcome this difficulty, I used the reflected light of an ordinary electric lamp, which causes the central chitinous duct of the gland to shine out, thus differentiat-

ing the glands from the surrounding muscles. This was also helpful in tracing their course in the head as sufficient light passes through the chitinous parts to enable the glands to be seen easily.

The glands were either fixed in Bouin's picro-formol or Henning's fluid to soften the chitinous lining for ordinary wax embedding. To cut sections of the anterior part of the head recourse had to be taken to celloidin-wax embedding method on account of the hard chitin which offers considerable difficulties in section cutting.

Sections were stained either with Heidenhain's iron-haematoxylin, in which case the secretory granules were clearly marked out or with muci-haematein to find out any traces of mucin in the glands.

Observations

Distribution of the salivary glands in the family Tenebrionidae:—I have dissected a number of forms belonging to different genera and species of Tenebrionidae to ascertain the presence or absence of salivary glands in them. The following table summarises my results :—

Table I

Name of species examined	Probable nature of food	Presence or absence of salivary glands
1. ***Gonocephalum brachelytra*** Gebien	Leaf mould and cowdung	Salivary glands present in all
2. ***G. elongatum*** Fairm.	Do	
3. ***G. hoffmannsegi*** Stev.	Do	
4. ***Curimosphaena fasciculatus*** F.	Cowdung	
5. ***Himatismus vageguttatus*** Fairm.	Leaf mould	
6. ***Hyperops lata*** Kraatz.	Do	
7. ***Opatrinus punctulatus*** Brull.	Leaf mould and cowdung	
8. ***Alphetobius diaperinus*** Panz.	Excreta of pigeon	
9. ***Rhytinota impolita*** Fairm.	Stored grain	
10. ***Tribolium ferrugineum.***	Flour	
11. ***Lasiodaclytus marcuatipes.***		
12. ***Scleron reitteri*** Geb.		
13. ***Gonocephalum strigatum.***		
14. ***Scleron latipes.***		
15. ***Adavius clavipes*** Muls.		
16. ***Blaps orientalis*** Sol.		

From the table given above, it is clear that salivary glands are present in sixteen species belonging to at least twelve genera of this family. In fact, I have found these glands in every member of the family I have dissected so far, and this leads me to think that they are probably present throughout the family.

Structure of the salivary glands:—The salivary glands in the family Tenebrionidae are very simple. They are a pair of long, tubular structures, almost thread-like in appearance and wavy in outline. (Figs. 1, 2, 3 and 4.) Anteriorly they open into the pre-oral cavity. Beyond the region of the head they lie one on each side of the oesophagus and are then extensively coiled in a spiral manner beneath and amongst the thoracic muscles. They lie ventral to the alimentary canal and always end blindly near the point of insertion of the first pair of legs. Though the glands are very long in certain cases, e.g., *Rhytinota impolita* Fairm. (Fig. 1) in

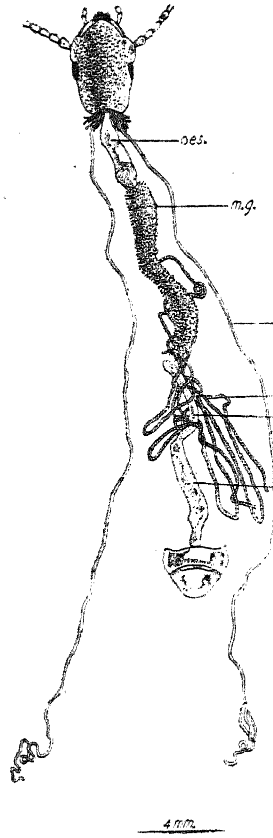

Fig. 1

The alimentary canal with the salivary glands (extended) of *Rhytinota impolita* Fairm.

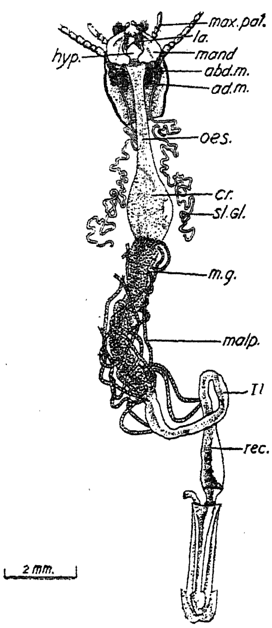

Fig. 2

The alimentary canal with the salivary glands (dissected in the head) of *Curimosphaena fasciculatus* F.

abd. m. abductor muscle of the mandible; ***ad. m.*** adductor muscle of the mandible; ***b. m.*** basement membrane; ***ca.*** cardo; ***cr.*** crop; ***du.*** duct; ***ga.*** galea; ***gl. cl.*** gland cells; ***hyp.*** hypopharynx; ***il.*** ileum; ***int.*** intima; ***la.*** lacinia; ***lab.*** labium; ***lab. pal.*** labial palp; ***lar. gr.*** larger granules; ***mand.*** mandibles; ***malp.*** malpighian tubules; ***m. g.*** mid gut; ***max. pal.*** maxillary palp; ***nu.*** nucleus; ***oes.*** oesophagus; ***rec.*** rectum; ***sl. gl.*** salivary gland; ***sm. gr.*** smaller granules; ***st.*** stipes.

which they are 4·16 cm. in length, I have never observed them extending beyond the region of prothorax. Sometimes, due to their great length, the coiled tubes also make several loops in the prothorax, but even in such cases the free blind end always remains near the insertion of the first pair of legs.

In the region of the prothorax, the glands always lie dorsal to the nerve cord and ventral to the thoracic muscles. In certain cases they are difficult to distinguish as they are extremely fine structures of about the same thickness as the muscle-fibres in which they remain entangled. But in a dissection under a binocular microscope, they are easily distinguished from the muscle-fibres with the help of the reflected light of an electric lamp, when the central chitinous duct of the gland becomes

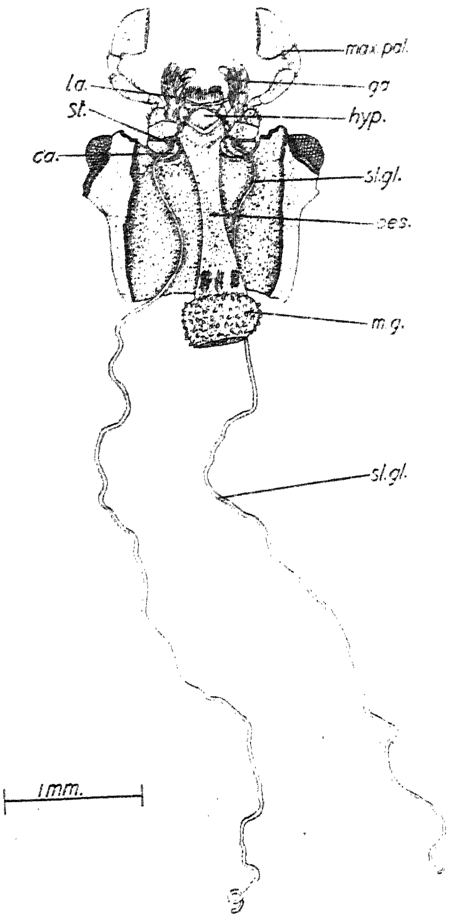

Fig. 3

Head of *Opatrinus punctulatus* Brull. dissected out to show the salivary glands.

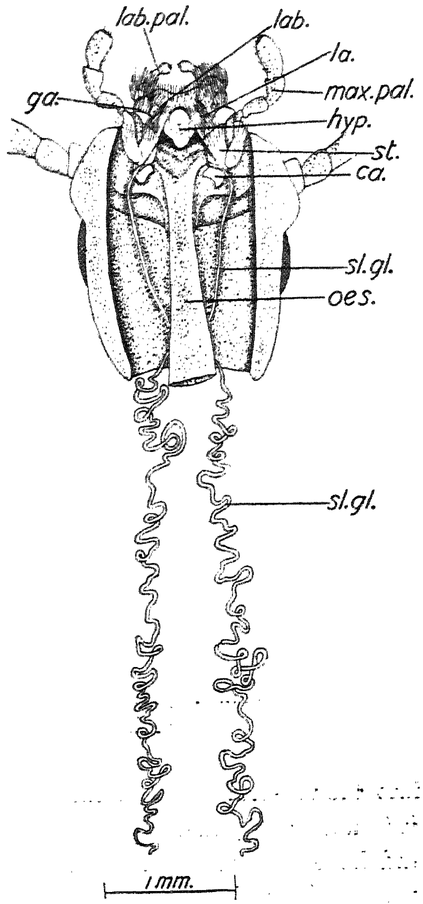

Fig. 4

Head of *Himatismus vageguttatus* Fairm. dissected out to show the salivary glands.

Lettering as in Fig. 1

sharply marked off from the surrounding cells and serves to distinguish the glands from the muscle-fibres. The duct is infinitely finer than its covering wall and has a uniform diameter throughout its length till it opens into the pre-oral cavity.

The glands enter the head-cavity along with the oesophagus (Figs. 2, 3 and 4) and at first remain close to it. But after a short course they diverge out on each side of the oesophagus, from their more or less median position, and run forwards and outwards amongst the head muscles. On passing beneath the abductor muscles of the mandibles (Fig. 2) they remain for a very short distance below the mandibles till they reach the postero-lateral angles of the maxillae. Each gland now turns mesially over the cardo and partly over the stipes (Figs. 3, 4 and 5) and opens directly

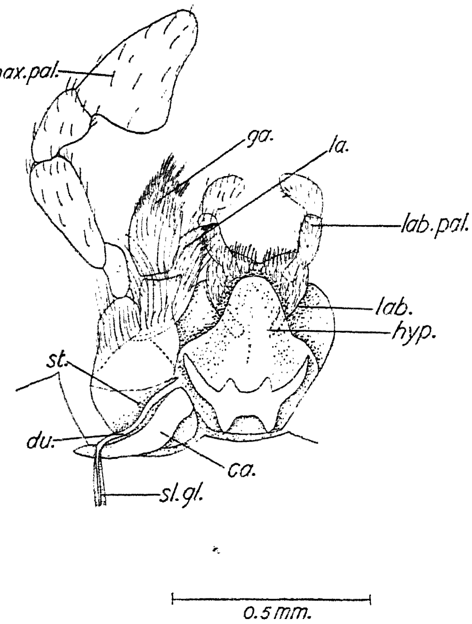

Fig. 5
Labium, hypopharynx and maxilla of one side of *Opatrinus punctulatus* Brull. to show the opening of the salivary glands.
Lettering as in Fig. 1

into the pre-oral cavity in the angle formed by the maxilla with the hypopharynx. It is noteworthy that the ducts of the two sides remain distinct from each other and have separate openings in the pre-oral cavity, unlike the case in *Pyrochroa coccinea* (Pyrochroidae) where they unite to form a common "*excretory canal*"* as has been described by Dufour.[1]

*It is difficult to understand why Dufour calls the common salivary duct as the ***excretory canal*** when functionally, according to his own statement, the glands are secretory in nature.

The glands have a uniform structure throughout their course both within the prothorax and the head except at the extreme anterior end where only the duct exists and the surrounding glandular part is absent. The thickness of the glands is also uniform throughout its length except for a short distance at their posterior end where they are slightly narrower.

A feature of the glands which is not always constant but which I have observed in a few cases, e.g., *Opatrinus punctulatus,* may be mentioned here. In this form, the free blind end of the gland often presents a bifurcation,* the structure and thickness of the two branches being the same. (Fig. 6 *a*). As this bifurcation of the free end was not noticed even in all the available specimens of this species, it does not appear to be a constant feature. But the branching is carried to the extreme in *Blaps orientalis* where the two main tubes give out numerous side branches, small and big, and these branch again, thus producing a network of ramifying tubes on either side of the oesophagus. The two main glands are slightly thicker than the branches but the structure of the branches as well as the main gland is the same as described in other cases.

The general arrangement of the glands is identical in nearly all the species that I have examined except in the case of *Blaps orientalis* and the description given above would apply equally well to all, only with this difference that the length varies widely in different species, while the thickness is more or less the same. In all the species, the two glands open separately into the pre-oral cavity, never uniting anteriorly to form a common "*excretory canal*" (Dufour) opening below the hypopharynx.

The glands are the longest in *Rhytinota impolita* Fairm. (Fig. 1), being about 4·16 cm. long and about 0·05 mm. or 50μ in cross section, while the inner chitinous duct is only about 0·0083 mm. or 8μ in thickness. In the normal condition they remain coiled in the prothorax but if extended they are found to be about $1\frac{1}{2}$ times the length of the intestine and about $2\frac{1}{2}$ times the length of the animal itself. The glands are also quite long in *Himatismus vageguttatus* Fairm. (Fig. 4) and *Curimosphaena fasciculatus* F. (Fig. 2) where they are nearly 1·42 cm. in length and 0·05 mm. in cross section, the thickness of the chitinous duct being about 0·0083 mm. or 8μ, while the length of the intestine is about 2·1 cm. Thus here the glands are slightly smaller than the intestine. *Gonocephalum brachelytra*, *G. elongatum* and *G. hoffmannsegi* possess glands of moderate size which are about 0·95 cm. to 0·73 cm. long and 0·03 mm. in cross section, while the intestine is about 2·17 cm. to 1·31 cm. long, thereby showing that in these three species, the glands are invariably smaller than the length of the intestine. In

*A similar phenomenon has been observed by me in some coccinellids also. There the salivary gland not only bifurcates but presents sometimes 3 or even 4 branches at its free distal end.

Opatrinus punctulatus Brull. (Fig. 3) the salivary glands are smaller than those described above but compared to the size of the gut and the insect they are not so small. The length of the glands is about 0·75 cm. and their thickness in cross section is about 0·037 mm., while the length of the gut is about 1·68 cm. Similar is the case in *Alphetobius diaperinus* Panz. In *Hyperops lata* Kraatz. also the glands are small, being only 0·55 cm. in length and 0·041 mm. in cross section, the length of the gut being 1·21 cm. In other species the glands are even smaller than these. The length of the glands though roughly constant in the same species varies slightly in individual specimens. The above data clearly point to the conclusion that the length of the glands is a variable feature in different species though the thickness of the duct and the gland is more or less constant throughout the family except for very small variations.

Histology of the salivary glands:—Histologically, the glands consist of three layers: the outermost covering is formed by the basement membrane and the innermost by the intima; between these two, there is a single layer of glandular cells. In a longitudinal section (Fig. 6 *b*) the innermost chitinous lining or the intima forms a fine narrow tube of uniform thickness, which is surrounded by a single layer of glandular cells which in turn is covered over by the basement membrane. This arrangement is retained throughout the length of the gland except at its two ends. At the extreme blind end the chitinous tube stops short while the glandular cells continue and form the extreme distal end (Fig. 6 *c*). At the extreme proximal end the glandular cells stop short and only the duct continues and opens into the mouth-cavity.

The glandular cells of the middle layer are small in size and have a uniform structure. They possess a big rounded nucleus which lies towards the outer wall of the cell. The cytoplasm is granular (Fig. 6 *e*) having two kinds of granules easily distinguishable by their size. The first kind are rather large and are only a little smaller than the nucleus and stain very deeply with iron haematoxylin. As a matter of fact, they take up the stain even before the nucleus does so. These granules are only a few in number in each cell. The second kind of granules are extremely small and lie scattered in the cytoplasm in large numbers; these do not stain so deeply with iron haematoxylin as the larger granules do.

In spite of the most careful methods of staining and examination I failed to notice any pores in the chitinous duct through which the secretion of the cells may be poured into its lumen. Hence I am inclined to believe that the intima is permeable to the secretion which finds its way into the chitinous duct by a process of osmosis.

In the case of branching glands of *Opatrinus punctulatus* or *Blaps orientalis*, the central chitinous ducts of the branches are continuous with the duct of the main

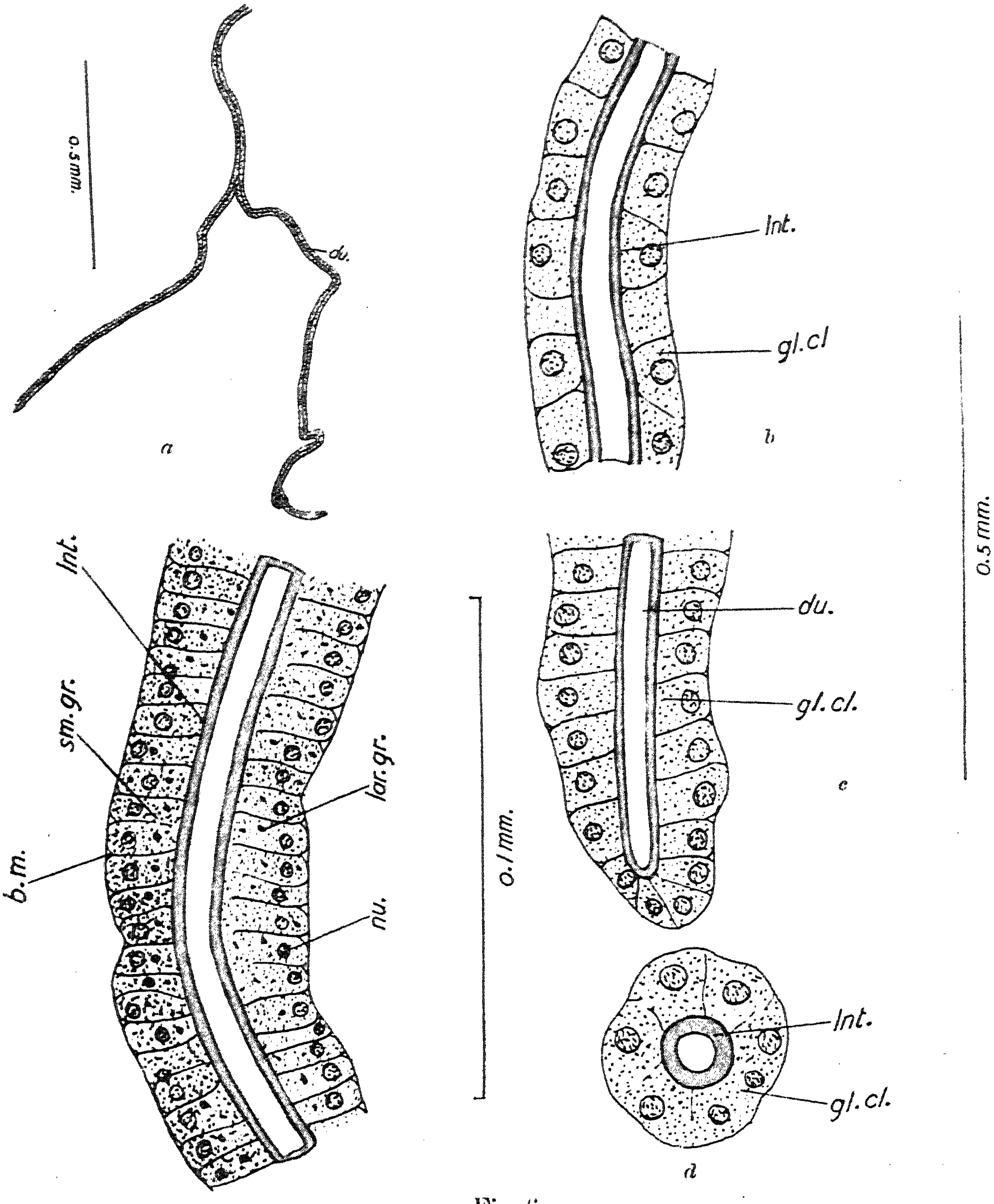

Fig. 6

a, Distal part of the salivary gland of ***Opatrinus punctulatus*** Brull. to show the branching of the free blind end; *b*, Long. Sec. of the salivary gland (in the head region) of ***Opatrinus punctulatus*** Brull.; *c*, Distal end of the salivary gland of ***Opatrinus punctulatus*** Brull.; ***d***, Tr. Sec. of the salivary gland of ***Opatrinus punctulatus*** Brull.; ***e***, Part of the salivary gland of ***Himatismus vageguttatus*** Fairm. stained with iron haematoxylin to show the granules in the cytoplasm.

Lettering as in Fig. 1

gland and their surrounding glandular cells are continuous with those of the main gland.

Physiology of the salivary glands:—On account of the very minute size of the glands, it was not possible to test the actual nature of their secretion. But the fact that mucin usually accompanies the salivary secretion and can be detected easily offered a clue for determining whether these glands are salivary in nature. As there are several good methods for the detection of the smallest amount of mucin in very fine ductules, I naturally turned to these in order to find out if there was any trace of mucin in the glands, since mucin forms part of the salivary secretion of many insects, as was shown by Sirodot [5] in the saliva of *Gryllus* and *Gryllotalpa*. I tried the mucihaematein method of P. Mayer which is a purely mucin stain. The glands thus stained clearly showed mucin granules stained violet, a fact which proved that the glands did secrete mucin and were most likely salivary structures. Whether the secretion acts on starch or on proteids or on both I had no means to determine as the structures are so minute and it would be extremely difficult to take out a sufficient quantity of the gland extract from such microscopic structures for digestive experiments.

Discussion and Conclusion

From the foregoing description of the structure of the salivary glands, it appears that they are one of the simplest types of salivary glands found amongst insects. Similar tubular salivary glands are found in different orders of insects, e. g., Lepidoptera, Psocoptera etc. The silk glands of the lepidopterous larvae, though much bigger, show a considerable resemblance to these glands in the histological structure except that the nuclei in the latter are not branched as they are in the case of silk glands; and secondly, the chitinous duct of the salivary glands does not show any transverse striations which are so characteristic of silk glands.

In Coleoptera, similar tubular glands have been described by Dufour [1] in *Pyrochroa coccinea* (Pyrochroidae) but his account differs substantially from my observations on the structure and disposition of these glands in the family Tenebrionidae. He writes:—

"Elles sont bien plus longues et peut-être plus fines que celles de la larva. Chacune d'elles est un filet tubuleux simple, plus délié qu'un cheveu, plus ou moins flexueux, et s'étént à-peu-près jusque vers le milieu du ventricule chylifique. Avec un fort grossissement, ce boyau capillaire paraît formé d'une tunique musculo-membraneuse plus ou moins plissié en travers, et d'un conduit central infiniment plus fin qui son enveloppe, et qui lui paraît peu adhérent; car lorsqu'on rompt le boyan, l' axe tubuleux fait souvent une saillie en dehors des bouts tronques, comme si l'enveloppe s'était rétractée au moment de la rupture. Cetté structure des

glandes salivaires s'observe très souvent dans les insectes de divers ordres. Avant de pénétrer dans la tête, la glande s'atténue en un col d'une ténuité presque imperceptible et les deux cols confluent ensemble pour la formation du conduit excréteur."

He further writes that similar glands were noticed by him in the Daipére, the Oedémères and the Mordelles but he gives neither a detailed description of the glands in these families nor any diagrams. Similar but very short glands were described by him even in the larva of *Pyrochroa coccinea* which he says could be noticed after great difficulty.

All the four families in which salivary glands have been described by Dufour, belong to the superfamily Heteromera to which also belongs the family Tenebrionidae. But the salivary glands in this family differ in some respects from the glands described by Dufour in the above-named families of Heteromera. The differences are as follows :—

Firstly, Dufour says that before entering the head the salivary glands become attenuated to form two extremely fine necks which unite together to form a "common excretory canal". In the Tenebrionidae, however, the glands do not unite to form one canal but open separately in the pre-oral cavity on each side, in the angle formed by the maxilla with the hypopharynx. Secondly, he describes the glandular cells surrounding the central chitinous duct as a musculo-membranous film, more or less creased crosswise and little attached to the duct. It is probable that Dufour's "Musculo-membranous film creased crosswise" is really the layer of glandular cells, the identity of which he could not recognise as he has given no description of them.

As I have already stated the salivary glands in this family are of a very simple type. The fact that the glands have a pair of separate openings in the mouth-cavity leads to the belief that they are probably more primitive than those where the opening is single as no doubt the single opening of the common salivary duct is a result of the secondary union of a pair of invaginations, which takes place during development. *Blaps* stands at a higher level than the rest of the Tenebrionidae as far as the development of the salivary glands is concerned. The ramifying tubules of *Blaps orientalis* are nothing but the result of further branching of the simple tubular glands of the rest of the Tenebrionidae, the indications of branching being occasionally seen in *Opatrinus punctulatus* where the blind end sometimes presents a bifurcation.

Though I have so far examined only about 16 species of this family which are commonly found round about Lucknow, I am inclined to think that salivary glands are present throughout the family.

It will not be out of place here to mention that similar glands have been discovered by me in a large number of the members of the family Coccinellidae and

also in some members of the families Curculionidae and Cerambycidae, an account of which will appear in due course.

Taking these facts into consideration it appears that simple, long and tubular salivary glands as described in this paper are the commonest type of salivary glands found amongst the Coleoptera. They have so far been overlooked by most workers probably on account of their minute size and also because they lie hidden amongst the muscles beneath the gut. The author believes that a careful search will reveal their existence in a large number of forms in which they are at present supposed to be absent.

The work was carried out in the Zoological laboratories of the University of Lucknow, India, under the kind guidance of Dr. K. N. Bahl, Professor of Zoology, whose constant help and keen interest in my work was a source of encouragement throughout. I take this opportunity of offering my respectful thanks to him. I am also very much thankful to Mr. M. L. Bhatia, Lecturer in Zoology, in the Lucknow University, for his constant help in the preparation of plates. I am deeply indebted to Dr. H. S. Pruthi, the Imperial Entomologist at the Pusa Agricultural Research Institute, for suggesting this piece of work and also for his kindness in getting the various species identified. I am also very thankful to him for his valuable suggestions and criticism of the paper. Grateful acknowledgments are due to the Lucknow University for the financial help given to me in the form of a Research Fellowship.

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NEW STREGEIDS (TREMATODA) FROM INDIAN BIRDS

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SUMMARY

Four new species, two belonging to the genus *Apharyngostrigea* Ciurea and two to the genus *Strigea* Abildgaard, are described. The genus *Ridgeworthia* Verma 1936 is dropped and the species is assigned to the genus *Apharyngostrigea.*

The genus *Apharyngostrigea* Ciurea (1927), hitherto includes only six species, *Aph. cornu* Goeze (Zeder) (1800), *Aph. simplex* Johnston (1904), *Aph. brasiliana* Szidat (1929), *Aph. garciai* Tubangui (1933), *Aph. flexilis* Dubois (1935) and *Aph. egretti* Verma (1936). In this paper are described two more species belonging to this genus, *Aph. ardeolina* n. sp. and *Aph. indiana* n. sp., both from the intestine of aquatic birds, *Ardea cineria cineria* and *Egretta alba* respectively.

The genus *Ridgeworthia,* proposed by Verma (1936) for certain Strigeids from the small intestine of herons is in my opinion quite untenable. This genus which is based only on the character of the holdfast organ, "a peculiar muscular ridge, bent upon itself with a prominent adhesive gland behind," resembles the genus *Apharyngostrigea* so closely in the form of the body, absence of the pharynx, distribution of the vitelline follicles, and general topography, that it is not possible to separate it from that genus. I therefore drop the genus *Ridgeworth* and assign it to the genus *Apharyngostrigea.*

1. *Apharyngostrigea ardeolina* n. sp. (Fig. 1)

Only two specimens of this parasite were obtained from the small intestine of the eastern grey heron, *Ardea cineria cineria,* shot near Phoolpore, Allahabad. The parasites when alive were white in colour and appeared sluggish. The body, 5·752—5·866 * in length is feebly muscular, aspinose and distinctly divided into fore and hind parts, by a fairly long and narrow 'neck region.' The deeply vase-shaped forebody, 2·344—2·784 in length and 1·312 in maximum width, across the acetabulum, is much attenuated posteriorly just in front of the adhesive gland where it

* All measurements are in mm.

measures 0·784 in breadth. The hind body is elongated, cylindrical and slightly flexed dorsally, measuring 3·52—3·56 in length and 0·72 in width.

The oral sucker is small, spherical or oval, measuring 0·176—0·18 in length and 0·186—0·2 in width. The acetabulum, 0·192—0·288 × 0·272—0·352, lies submedian at the end of the anterior third of the forebody. The pharynx is absent. The fairly long oesophagus bifurcates in front of the acetabulum into thin-walled intestinal caeca, whose course behind the acetabulum could not be traced on account

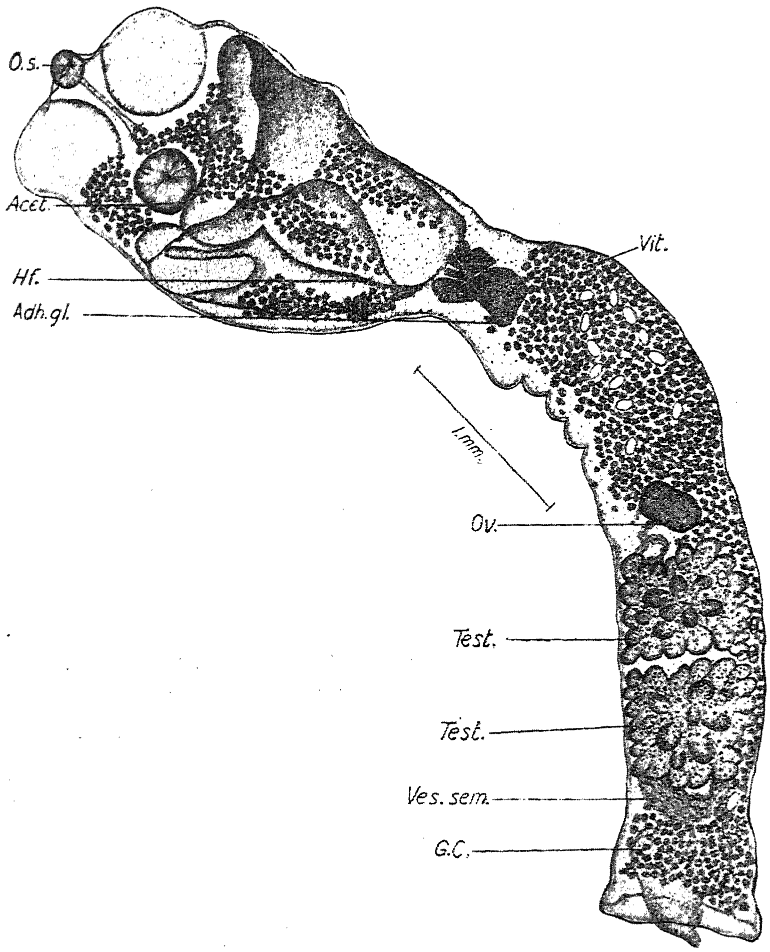

Fig. 1

Apharyngostrigea ardeolina n. sp.

Acet. acetabulum; *Adh. gl.* adhesive gland; *Atr.* genital atrium; *D. ej.* ductus ejaculatorius; *G. C.* genital cone; *H.f.* holdfast organ; *I. c.* Intestinal caecum; *L. S. P.* lateral suctorial pocket; *O. S.* oral sucker; *Ov.* ovary; *Ph.* pharynx; *Test.* testis; *Ut.* uterus; *Ves. Sem.* vesicula seminalis; *Vit.* vitellaria; *Y.r.* yolk reservoir.

of the large holdfast organ and closely crowded vitelline follicles, both in the fore and hind parts. The holdfast organ of 1·36 length is bilobed, occupying practically the whole of the space between the adhesive gland and the acetabulum. The adhesive gland of 0·48—0·52 × 0·304—0·45 size, is composed of closely aggregated, small anterior and broad posterior lobules which occupy the entire 'neck region.'

The gonads lie in the posterior two-thirds of the hind body. The large multilobulated testes are situated 0·08 mm. behind one another; the anterior testis, 0·56—0·64 × 0·64 in size, is somewhat smaller than the posterior one which measures 0·72 × 0·704. The vesicula seminalis, situated postero-dorsal to the second testis, is feebly muscular and slightly coiled. The ovary is oval, sub-median, and situated somewhat obliquely in front of the anterior testis, at the end of the anterior one-third of hind body, measuring 0·192 in length and 0·32 in width. The oviduct arises from the postero-dorsal side of the ovary and after describing a few convolutions in front of the anterior testis gives off the Laurer's canal. The shell-gland complex lies as usual between the two testes. The uterus as soon as it emerges from the ootype runs forwards almost to the 'neck region' and there it bends on itself to continue its more or less straight downward course to the posterior end. The terminal part of the uterus along with the end-part of the ejaculatory duct, opens at the apex of the genital cone. The genital atrium is spacious and the genital pore is terminal. The mature eggs measure 0·064—0·095 × 0·064—0·08 in size. The vitelline follicles are profusely developed both in fore and hind parts. In the region of the holdfast organ, they lie in three more or less well-defined and fairly broad longitudinal bands; only a few follicles, however, extend a little ahead of the acetabulum. In the 'neck region' the follicles are entirely absent. In the hind body they are more extensive, occupying most of the space not otherwise occupied by the reproductive organs and extending almost to the posterior end. The vitelline reservoir lies between the testes.

Remarks:—*Apharyngostrigea ardeolina* n. sp. differs from *Aph. cornu*, *Aph. simplex*, *Aph. brasiliana*, *Aph. flexilis*, and *Aph. egretti* in the multilobulated form of its testes—a feature in which it resembles *Aph. garciai* and *Aph. indiana* n. sp. From the two latter species it is easily distinguished by the shape of the body, position of the gonads, shape of the ovary, extent of the vitellaria, presence of a distinct 'neck region' and the large size of the adhesive gland

2. *Apharyngostrigea indiana* n. sp. (Fig. 2)

This species is a common parasite found in the intestine of *Egretta alba* at Allahabad. The distomes live firmly attached to the walls of the intestine. In the living condition they are white in colour and possess remarkable power of contraction and expansion. The body, 5·216 in length, is distinctly divided into

deeply cup-shaped and widely open forebody, 1·032 in length, 1·05 in breadth across the acetabulum, and cylindrical greatly flexed hind body, measuring 3·88 in length and 0·88 in maximum width. The ratio in the length of fore and hind parts is about 1 : 3.

The oral sucker is terminal and spherical, measuring 0·15 in diameter. The acetabulum, 0·272 in diameter, lies median much in front of the middle of the fore-body. The pharynx is absent, the oesophagus is short and tubular, measuring 0·135 in length. The intestinal caeca run on either side of the acetabulum, through the basal part of the holdfast organ to the sub-caudal region. In the hind body their course is masked by the presence of the closely crowded vitellaria. The holdfast organ is 0·72 long and 0·88 broad, occupying greater part of the post acetabular

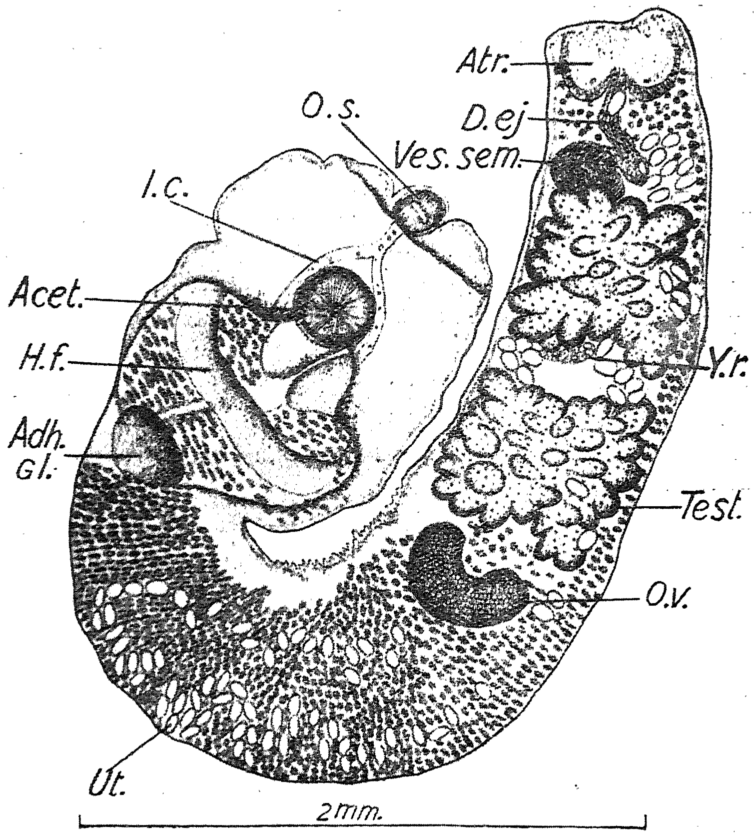

Fig. 2

Apharyngostrigea indiana n. sp. Lettering as in Fig. 1

region of the forebody. It has the shape of a shallow thick walled cup incomplete below, having a large thick circular lappet, with a deep narrow median incision, attached to its anterior margin. The adhesive gland is a cluster of closely aggregated lobules, measuring 0·24 in length and 0·32 in breadth. It is transversely oval and situated close behind the holdfast organ. The dorso-lateral muscle bands are strongly developed.

The gonads occupy the posterior two-third part of hind body. The multilobulated somewhat transversely elongated testes lie tandem 0·08 mm. behind one another, in the posterior half of hind body. The anterior testis is larger, measuring 0·56 in length and 0·704 in width. The posterior testis measures 0·592 × 0·6 in size. The large somewhat coiled vesicula seminalis lies postero-dorsal to the second testis. The ovary is transversely elongated, semilunar in shape, measuring 0·16 in length and 0·432 in width. The shell gland and vitelline reservoir are intertesticular in position. The uterus extends anteriorly to about 0·288 mm. behind the body constriction and there it bends on itself to continue its backward course as a sinuous descending limb, situated ventrally to the gonads. The genital cone is present and the genital atrium is spacious. The genital pore is large and terminal. The mature eggs measure 0·32 × 0·112 in size. The vitellaria are extensively developed, extending anteriorly as far as the centrum of the acetabulum and posteriorly to the anterior margin of the genital atrium.

Remarks :—This species differs from all the occidental species and *Aph. egretti* Verma (1936) on account of the multilobulated testes, form of the holdfast organ, and size of the ova. It stands closest to *Aph. garciai* Tubangui (1933) on account of the form of the testes and size of the body. But it differs in the form of the body, ratio in the size of the suckers, shape of the ovary, position and size of the testes, the extent of the uterus and the vitellaria, and the size of the ova.

3. *Strigea orientalis* n. sp. (Fig. 3)

Numerous specimens were obtained from the small intestine of the King vulture, *Sarcogyps calvus*, shot in the suburbs of Allahabad in November 1936. The distomes, 3·312—3·71 in length, have a muscular body which is distinctly divided into fore and hind parts. The forebody, 1·2—1·52 long and 1·06—1·08 broad across the acetabulum, is deeply cup-shaped and armed with numerous very minute, backwardly directed spines. The hind body is somewhat dorsally flexed, 2·112—2·208 × 1·12—1·168 in size, broad anteriorly, narrow and somewhat rounded at the posterior extremity. The ratio in the length of the two parts is 4 : 7.

The oral sucker is sub-terminal, measuring 0·144 long and 0·112—0·128 broad. The acetabulum, 0·24 × 0·288 in size, *i.e.*, about twice the size of the oral sucker, lies median at the equator of the forebody. The prepharynx is absent. The pharynx is muscular and somewhat barrel-shaped, measuring 0·096 in length and 0·112—0·128

in width. The oesophagus is short and tubular. The intestinal caeca run on either side of the acetabulum, terminating a little in front of the posterior extremity. The powerful longitudinal muscle fibres which originate from the base of the lateral suctorial pockets, situated one on each side of the pharynx, form the dorsolateral musculature in the hind body. The holdfast organ which is divided anteriorly into two or three lamellae, lies at the base of the forebody, hardly protruding beyond the anterior margin of the acetabulum. The adhesive gland, a compact mass of small elongated somewhat triangular lobules, lies at the base of the holdfast organ.

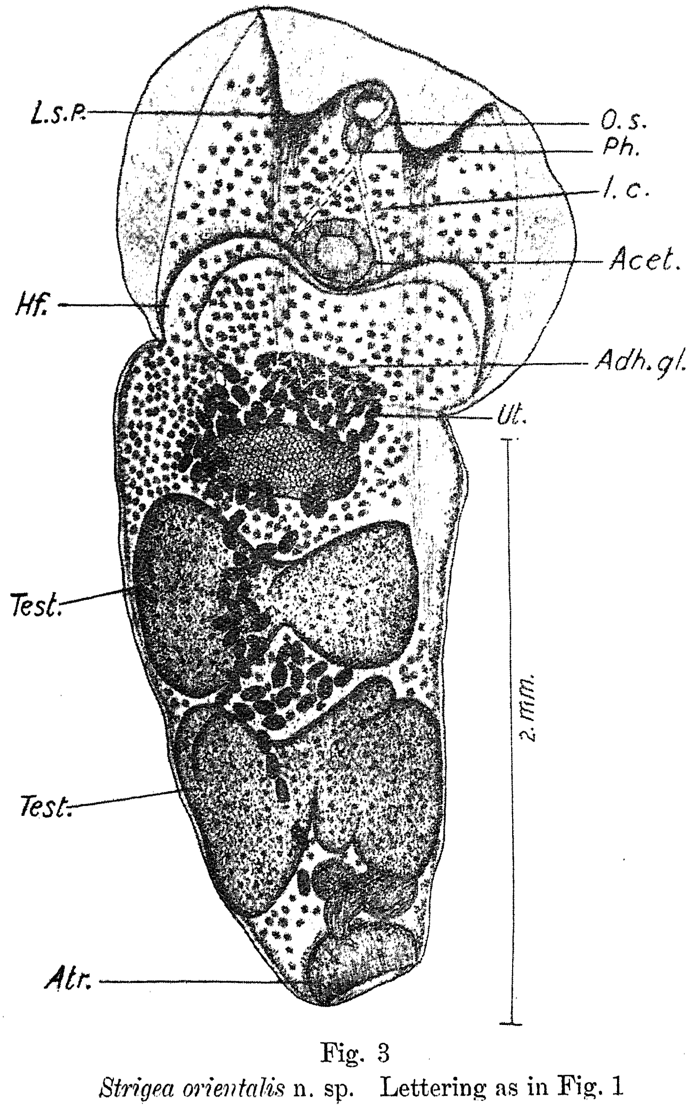

Fig. 3
Strigea orientalis n. sp. Lettering as in Fig. 1

The gonads practically occupy the whole of the hind body. The testes, 0·628–0·752 × 0·938–1·12 in size, are dumb-bell-shaped, broadly lobate and situated close behind one another in the posterior three-fourth part of hind body. The slightly coiled vas deferens, formed by the union of the two vasa-efferentia close in front of the anterior testis, passes backwards ventrally to the testes as a slightly sinuous duct, 0·08 in diameter, before it becomes enlarged to form the muscular, S-shaped vesicula seminalis, situated postero dorsal to the second testis. The ovary, 0·244–0·32 long and 0·44–0·65 broad, lies median a little in front of the anterior testis. The shell gland and vitelline reservoir are both intertesticular. The uterus extends anteriorly to the body constriction. Its distal end and the terminal portion of the ejaculatory duct open through a small genital cone into a spacious genital atrium of 0·288 length and 0·608 width. The genital pore is terminal. The eggs are yellow, operculate, large in number, measuring 0·032 × 0·096 in size. The vitellaria extend anteriorly as far as the level of the pharynx and posteriorly to the beginning of the genital atrium.

Remarks :—The new species differs from *S. strigis* Goeze (1782), *S. infundibuliformis* Dubois (1934), and *S. elongata* Yamaguti (1935), in the much smaller size of the body and the genital cone and the position of the gonads. It can be distinguished from *S. nugax* Szidat (1927) by the large size and bell-shaped form of its bursa and from *S. bulbosa* Brandes (1888) by the ratio in the length of the fore and hind body regions. It is separated from *S. sphaerula* Rud. (1802), *S. unciformis* Rud. (1802), *S. elliptica* Brandes (1888), and *S. intermedia* Szidat (1932) on account of the larger size of the body and the form of the testes—dumb-bell-shaped and broadly lobate in the new species but somewhat spherical in others. *S. orientalis* n. sp., however, resembles *S. falconis* Szidat (1928) with its two varieties, *i.e.*, *S. falconis* var. *brasiliana* Szidat (1929) and *S. falconis* var. *meleagris* Harwood (1932) and *S. mcgregori* Tubangui (1932) in the presence of the cuticular spines on the forebody, lobed condition of the testes, small size of the genital cone, and extent of the vitellaria. But it differs from them in the greater length of the body, position of the gonads in the nine-tenth part of the hind body, size of the testes which do not overlap each other, larger size of the suckers, and almost double size of the ovary. *S. vaginata* Brandes (1888) has been assigned by Lutz (1935) to a new genus *Gongylura*, on account of its exceptionally large genital cone.

4. *Strigea nephronis* n. sp. (Fig. 4)

Only two specimens of this parasite were obtained from the intestine of the Scavenger vulture, *Nephron percnopterus ginginianus*, in October 1936. The infection is very rare, as only one out of over a hundred hosts examined, was found infected. The body, 2·23 in length, is distinctly marked off into deeply cup-shaped

widely open forebody of 1·12 length and 1·04 breadth and cylindrical hind body, 1·2 in length and 0·608 in width.

The suckers are spherical and muscular. The oral sucker is terminal, measuring 0·176 in diameter. The acetabulum is situated medially at the end of

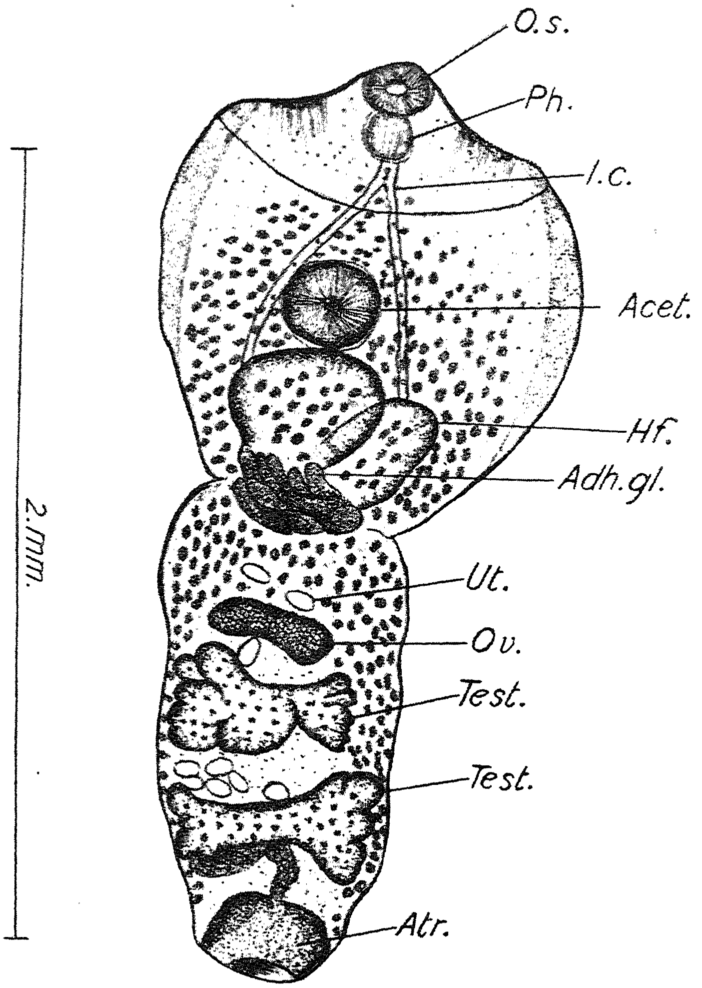

Fig. 4
Strigea nephronis n. sp. Lettering as in Fig. 1

the anterior half of the forebody and measures 0·24 in diameter. The prepharynx and oesophagus are entirely absent. The pharynx is muscular and oval or spherical, measuring 0·112 in diameter. The intestinal caeca extend on either side of the acetabulum through the basal part of the holdfast organ to near the anterior

margin of the genital atrium. The holdfast organ is broad, thick and bilobed and lies behind the acetabulum. The adhesive gland, 0·367 × 0·269 in size, is a compact mass of closely aggregated and somewhat elongated lobules, situated close behind the holdfast organ.

The testes are lobed and situated 0·08 behind one another. The anterior testis is situated more towards the right, and a little in front of the equator of the forebody, measuring 0·32 in length and 0·496 in breadth. The posterior testis is broader, measuring 0·304 × 0·544 in size. The ovary, 0·112 × 0·352, lies close in front of the anterior testis. The shell gland and vitelline reservoir lie in between the testes. The uterus extends anteriorly to about half the distance between the body constriction and the ovary. The ova are yellow, operculate and a few in number, measuring 0·05 – 0·06 × 0·08 – 0·1 in size. The genital atrium, 0·204 × 0·32 in size, is large; the genital pore is terminal. The vitellaria extend anteriorly to the level of the pharynx and posteriorly to the beginning of the genital atrium.

Remarks :—In its affinities, *S. nephronis* n. sp. stands nearest to *S. bulbosa* Brandes (1888) on account of the equal length of the fore and hind body regions, absence of the spines and prepharynx, size of the acetabulum and the extent of the vitellaria. But it differs from *S. bulbosa* in the smaller size of the body, distinct division of the body into fore and hind parts, very conspicuous adhesive gland, ratio in the size of the two suckers and the position and form of the testes.

The author is indebted to Dr. H. R. Mehra for his valuable guidance and to Prof. D. R. Bhattacharya for the facilities provided in the Department.

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PROSOTOCUS HIMALAYAI N. SP., A FROG TREMATODE (LECITHODENDRIIDAE)

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SUMMARY

To the four species of the genus *Prosotocus*, hitherto reported from frogs, is added *P. himalayai* n. sp. from *Rana cyanophlyctis* at Bhimtal (Kumaon Hills). The new species, described in this paper, differs from the other species in the position of its vitellaria.

During an examination of *Rana cyanophlyctis* from Bhimtal (Kumaon Hills) for endoparasitic trematodes, two frogs were found infected with three specimens of a trematode belonging to the genus *Prosotocus* Looss, 1899. Up to the present moment four species of this genus are known to parasitize frogs, viz., *Prosotocus confusum* Looss 1894; *Prosotocus indicus* Mehra and Negi, 1928; *Prosotocus fuelleborni* Travassos, 1930; and *Prosotocus infrequentum* Srivastava, 1933. The present form, after comparison with these four species, has been found to possess well-marked differences which necessitate the creation of a new species for its reception.

Prosotocus himalayai n. sp.

Description :—Body elliptical, 0·88 in length* and 0·38 in breadth. Cuticle covered with spines. Oral sucker subterminal, broader than long, larger than acetabulum, with mouth opening directed ventrally, 0·094 × 0·12 in size; prepharynx present; pharynx 0·03 in size; oesophagus, 0·16 in length; intestinal bifurcation just in front of anterior third of body length; caeca extending beyond posterior limits of acetabulum and terminating 0·13 distance behind middle of body length. Acetabulum, situated at middle of body length, 0·1 in diameter. Excretory pore terminal. Genital atrium shallow, situated ventrally midway between oral sucker and anterior testis nearer left body margin, 0·03 × 0·09 in dimensions. Testes pre-acetabular, asymmetrically placed; anterior testis sinistral, almost oval, smaller than posterior testis, situated externally to posterior half of oesophagus, 0·1 × 0·07 in size; posterior

*All measurements are in millimeters.

testis, situated just behind anterior one, extra-caecal on the right side, 0·09 × 0·1 in size. Cirrus sac large, elongated, curved anteriorly, consisting of basal saccular half somewhat obliquely placed between anterior testis and body wall with its posterior end touching anterior acetabular limits and narrower anterior half lying

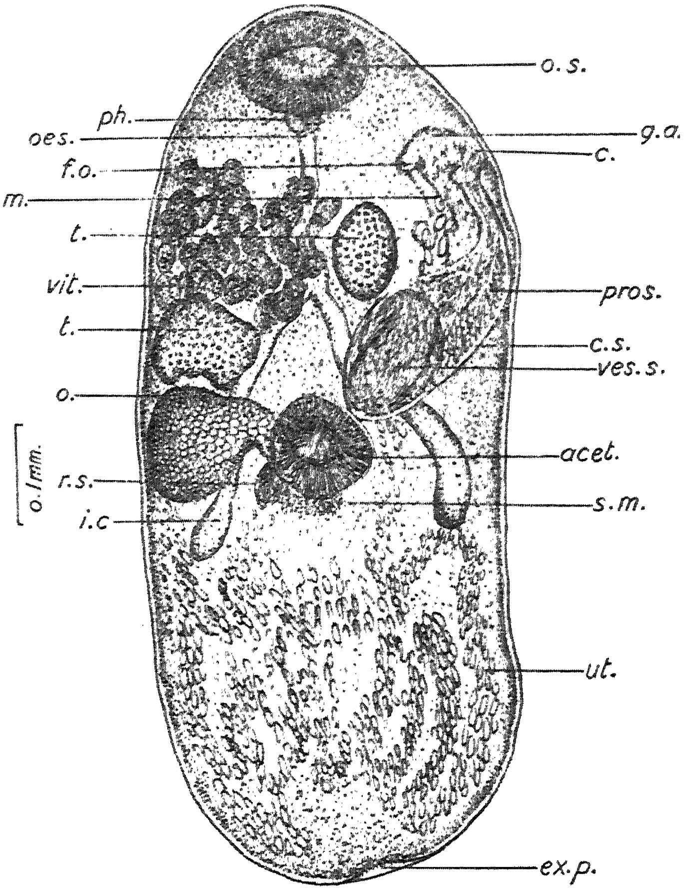

Fig. 1

Prosotocus himalayai n. sp., Ventral view.

acet. acetabulum; *c.* cirrus; *c. s.* cirrus sac; *ex. p.* excretory pore; *f. o.* female opening; *g. a.* genital atrium; *i. c.* intestinal caecum; *m.* metraterm; *o.* ovary; *oes.* oesophagus; *o. s.* oral sucker; *ph.* pharynx; *pros.* prostate gland cells; *r. s.* receptaculum seminis: *s. m.* shell gland mass; *t.* testis; *ut.* uterus; *ves. s.* vesicula seminalis; *vit.* vitellaria.

near and parallel to left body wall, 0·3 in length and 0·1 in maximum breadth. Vesicula seminalis in basal half of cirrus sac, composed of much swollen sac-like proximal part and coiled distal part opening into spherical pars prostatica, 0·036

in diameter; well-developed prostate gland cells present; ductus ejaculatorius in narrower terminal half, opening into genital atrium through male pore near body wall. Ovary somewhat pearshaped, to right side of acetabulum, lying mostly outside and ventrally to caecum of that side, larger than testes, 0·12 × 0·13 in size; receptaculum seminis nearly spherical, 0·06 × 0·05 in size, situated along with shell gland mass and yolk-reservoir postero-dorsally to acetabulum; descending and ascending limbs of uterus occupying post-acetabular space, the latter on reaching acetabular level proceeds forwards to open into well-developed metraterm near posterior level of anterior testis; metraterm opens into genital atrium by a separate pore situated at 0·036 distance apart from male opening; ripe eggs elliptical, yellowish, 0·0288 × 0·0144 in size; vitelline follicles crowded on right side only, extending from a little behind pharynx to about anterior end of posterior testis, with a few follicles overlapping oesophagus. The position and distribution of the follicles indicates that vitelline gland of right side is only present and this is confirmed by the presence of one vitelline duct from the follicles which runs backwards between ovary and acetabulum to open into yolk reservoir.

Remarks :—This species, on account of the position of genital atrium with separate male and female openings, terminal excretory pore, position of asymmetrically situated testes, and the smaller size of the left testis comes closer to *Prosotocus infrequentum*, parasitic in the duodenum of *Rana cyanophlyctis* in Sitapur but it can easily be distinguished from it in the following respects:—smaller body size, size-ratio of suckers, greater length of intestinal caeca, position and size of ovary, position of shell gland mass and receptaculum seminis, smaller length of eggs, size of vitelline follicles and the peculiar one-sided position of the vitellaria. The last character is the most outstanding feature in which *P. himalayai* n. sp. is sharply separated off from all the species of the genus *Prosotocus* hitherto described from frogs.

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